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# Get-Away Special: The Low-Cost Route to Orbit

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# THE LOW-COST ROUTE TO ORBIT

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## ABSTRACT

NASA has established the Get Away Special (GAS) program as a means for providing anyone who wishes the opportunity to place a small self-contained experimental payload aboard a Space Shuttle mission for a very low cost. The GAS program is now well established, and has a respectable history with 53 payloads flown to date. The GAS experimenters are a diverse group who have demonstrated that people from all walks of life, and from many nations, are interested in working in space.

This paper traces the history of the program from its concept through the development phase to the present time, and takes a brief look at the future. It also addresses the steps involved in making a payload reservation and the programmatic and technical relationships that are established between NASA and GAS customers.

## INTRODUCTION

Background. In the mid-1970's, with production of the first flight Orbiter nearing completion, NASA began to perform payload manifesting exercises. As experience was gained manifesting various combinations of major payloads, it became obvious that there would often be small amounts of volume and weight capability remaining following installation of the major payloads. Discussions on various alternatives of how to make effective use of that "leftover" capability led to the creation of the GAS program.

NASA announced the GAS program to the aerospace community during a meeting of the American Institute of Aeronautics and Astronautics in December 1976. Before the conference had ended, Mr. R. Gilbert Moore, an executive of the Thiokol Corporation, committed his personal resources to purchase the first GAS payload reservation. Mr. Moore later donated his payload to Utah State University in Logan, Utah.

Soon after announcing the program, the Sounding Rocket Division at the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland was given the task of designing and developing the hardware and systems to support and operate the GAS program. The Sounding Rocket Division by that time had managed sounding rocket projects for 20 years. During that time the Division accumulated a great deal of experience in working on varied projects of short duration with limited resources very "hands on" approach to accomplishing their mission. This experience has proved to be of great value in designing and operating the GAS program, considering that some GAS experimenters begin their projects with very little knowledge of how to organize or manage a science oriented project. Now known as the Special Payloads Division it continues in the Space Shuttle era to operate the GAS program in the same straightforward manner.

From the beginning, GAS containers were intended to provide an envelope which would safely isolate the payloads from the Orbiter, and the concept of the GAS container as a pressure vessel was well established before the actual design work began. This concept was the basis for choosing the form of a relatively thin walled cylinder with thicker plates on either end. It was also agreed from the start to offer three sizes of payload weight and volume for the experimenter to choose from, and to charge for GAS payloads in a manner similar to major payloads, based on weight and volume. The prices charged for GAS payloads remain the same as originally announced:

2 1/2 Cubic Feet X 60 Pounds ---- $3,000.00

2 1/2 Cubic Feet X 100 Pounds ---- $5,000.00

5 Cubic Feet X 200 Pounds --- $10,000.00

While design work was getting under way at Goddard, personnel at NASA Headquarters began to define the policy which would become the rule for operating the program. NASA Headquarters and the GSFC began their respective tasks while more and more prospective customers began to purchase GAS payload reservations. By the time the proposed policy was published, earnest money payments had been received for more than 320 payloads.

Following completion of the proposed policy, a copy was mailed to each customer who had purchased a GAS payload reservation to date along with an invitation to attend one of two briefings on the policy. The briefings were held at the GSFC in Greenbelt, Maryland and the Jet Propulsion Laboratory in Pasadena, California. Many comments were received by NASA both during the briefings, and throughout the 90-day comment period that followed publication of the proposed policy. The first of two comments heard most often was the concern with tying prices to the inflation rate, which by this time would have almost doubled the prices originally proposed. The second concern was with the restriction on performing experiments only in closed containers which was the original intent of the program. Following review of all comments received, NASA agreed to freeze the prices for at least the first three operational years, and committed to providing a Motorized Door Assembly (MDA) for an optional services fee, which would allow GAS payloads to be exposed to space during flight. Making a GAS payload reservation continued to be a simple process. Upon receipt of a non-refundable earnest money payment of $500 for each GAS payload reservation desired, NASA will issue a payload reservation number and begin negotiations with new customers.

The design and construction of a NASA Flight Verification Payload (FVP) began while development and testing of standard GAS flight systems continued at Goddard. The intent of the FVP was to measure the environment within a GAS container during an actual mission. The FVP was designed to measure accelerations and pressure changes inside the container and to measure temperatures both inside and outside the container as a means of determining the effectiveness of the passive insulating system. The FVP was flown on STS-3, launched on March 22, 1982. The primary mission of STS-3 was to stress the Orbiter thermally which gave the FVP the opportunity to measure extreme temperature differentials. During STS-3, the cargo bay was oriented towards both deep space and the Sun for longer periods than those which normally occur during operational Shuttle missions.

The FVP gathered a great deal of data which was subsequently published and shared with GAS experimenters. This data was also incorporated into later revisions of the GAS Experimenter Handbook, and into a thermal design summary published at Goddard. Perhaps equally as important as the data gathered were the lessons learned by taking an actual payload through the review process, transporting it to the Kennedy Space Center (KSC), and working it through the integration process and all of the steps that led up to installation in the Orbiter. This experience gave the GAS team the opportunity to deal with the actual working conditions that would soon be shared by the experimenters. Initial working contacts were made with personnel at the Johnson Space Center and the KSC during the development and integration of the FVP that remain valuable to the GAS program to this day.

The first GAS payload was launched just over 3 months after the FVP on June 27, 1982. G0001 was the payload which had been purchased by Mr R. Gilbert Moore when the GAS program was announced in December 1976 (see figure 1). Mr Moore's payload was designed, fabricated, integrated and tested by students at Utah State University in Logan, Utah. Under the supervision of Dr. Rex Megill, other faculty members, and several interested personnel of the Thiokol Corporation in Wasatch, Utah, a very ambitious payload was conceived and executed. The payload contained 10 experiments, each contributed by an individual student. The large number of experiments complicated the integration process considerably, and the payload may have been as much of a challenge to NASA as it was to Dr. Megill and his students. Looking back, it was an excellent subject for NASA for the first GAS payload to be reviewed, certified, and flown. Lessons learned by NASA during the review and safety certification of G0001 have benefited every GAS payload that has followed in its footsteps.

Both the FVP and G0001 had been integrated in Hangar S located in the industrial area on the Canaveral Air Force Station. By this time, the Shuttle program was expanding and space to integrate payloads began to be more and more difficult to find. A search for a facility dedicated to the integration and support of GAS payloads resulted in the assignment of a building, which had orginally built for preparation of Delta rocket third stage motors to the GAS program. That existing building was enhanced by the addition of office space in the form of a mobile home. The GAS Preparation Facility is located on the Canaveral Air Force Station about 10 miles from the Orbiter Processing Facility (OPF) complex. This facility is used only by the GAS program which is of considerable value to the customer. At any given time, GAS payloads are either in the experimenter's hands or at the GAS Preparation Facility or in the Orbiter. A typical GAS payload integration is a cooperative affair between NASA and the experimenter lasting no more than 3 days. Following container closeout, GAS payloads remain in the GAS Preparation Facility until they are delivered to the Orbiter for installation.

The first mission to fly more than one GAS Payload was STS-6 launched on April 4, 1983, which carried three GAS payloads into orbit. They were G0005 (sponsored by the Asahi Shimbun of Tokyo, Japan), G0381 (sponsored by the George W. Park Seed Company of Greenwood, South Carolina), and G0049 (from the United States Air Force Academy in Colorado Springs, Colorado). The next mission, STS-7, launched on June 18, 1983, was the first large scale mission for the GAS program, carrying seven GAS payloads into orbit. While STS-6 had been a challenge, STS-7 was a real test of the GAS team's ability to plan and conduct a relatively large scale field operation. Since the GAS preparation facility is only big enough to work on three payloads at a time, STS-7 was the first that the GAS team found it necessary to plan and conduct a flow of payloads through the facility. After integration into the containers, all seven payloads were stored at the GAS facility until their scheduled installation into the Orbiter by the payload installation crew.

Design of the MDA began soon after the committment had been made. The design goal was to develop a mechanism that could be used either with or without a window while providing the largest opening possible. The first flight of the MDA occurred on STS-7, launched on June 18, 1983. The first GAS payload to use the MDA was G0305, sponsored by the United States Air Force, and designed, fabricated, and operated by the United States Naval Research Laboratory in Washington, D. C. G0305 was an experiment which measured ultraviolet radiation. The experiment required that the door be opened and closed several times and was a good subject for the first use of the MDA. The MDA is available to GAS experimenters as an extra cost option. The $7,000 fee charged for use of the MDA is intended to cover the costs of refurbishing the mechanism.

As NASA began to work with more and more customers, a conscious effort was made to develop a review process that would allow NASA to efficiently monitor the progress of payloads as they moved through the various steps leading to flight certification. As is the case for all payloads that fly aboard shuttle missions, the final authority for safety certification is the Safety Review Board at the JSC. For GAS payloads, the board has delegated responsibility for preliminary review to the GAS Project Office at Goddard; the end result being that the GAS experimenter has to deal only with personnel at Goddard for all of his technical concerns, and the GAS Project Office deals with the JSC Safety Review Board on the GAS experimenter's behalf. Goddard personnel maintain a close day-to-day working relationship with Safety Review Board personnel at the JSC.

The review process begins when the GAS experimenter mails his Payload Accommodation Requirements (PAR) to the Technical Liaison office at Goddard. This is NASA's first look at what the experimenter plans to do with his payload. Upon receipt of the PAR, Goddard assigns a NASA Technical Manager (NTM) to the payload. The NTM is a NASA engineer or technician who will help move the payload through the review process, assist in preflight preparation at the launch site, and most important, provide a single point of contact to deal with the customer's Payload Manager. Following review by Goddard, a marked up copy of the PAR is returned to the Payload Manager and a working telephone conference is scheduled. Upon agreement by all parties, a baseline PAR is signed. Three additional reviews must be completed before the payload is certified for flight; a Preliminary Safety Review, a Final Safety Review, and a Phase Three Safety Review. These reviews are performed in a similar fashion (in sequence) and they are the process by which NASA comes to know the payload in ever increasing levels of detail. For most payloads, the entire process takes 13 months from submission of the PAR to final signature of the Phase Three Safety Data Package.

Currently, NASA finds that some 60 to 70 payloads are likely to be under review at any given time. The GAS team at Goddard reviews the progress of those payloads on a weekly basis in an attempt to see that the payloads proceed on their working schedules. As flight opportunities arise, payloads that are either certified for flight, or promise to have completed the review process before field operations begin, are considered for flight assignment and those payloads are manifested in accordance with the queueing rules specified by the policy.

From the very earliest days of the GAS program, response from those who would form the GAS community has been both heavy and constant. Initally, NASA originally planned to fly GAS payloads on an adapter beam which would attach two payloads at a time to the Orbiter. As the number of GAS payload reservations grew, concern began to arise over how to handle the backlog of payloads that was accumulating. It was decided to build a structure that would span the Orbiter cargo bay and provide with the capacity to carry 12 GAS payloads at a time. Known as the GAS bridge, this structure is intended to be able to take advantage of the opportunity presented when a major payload encounters problems and becomes unable to meet its scheduled launch date (see figure 2). Following preliminary studies by NASA, and competitive bidding, the Teledyne Brown Engineering of Huntsville, Alabama was selected to design and fabricate the GAS bridge. NASA took delivery of the GAS bridge in September of 1984. Initial plans to fly the bridge for the first time were cancelled when NASA undertook the recovery of two satellites in November 1984 on mission STS 51-A. The first flight of the GAS bridge later took place on mission STS 61-C in January 1986. A total of 13 GAS containers flew on that mission. Twelve payloads were mounted on the GAS bridge which was located near the aft end of the cargo bay. One container on the bridge carried an engineering payload conceived by NASA to measure the launch and landing forces on the bridge, and the other twelve containers carried GAS payloads. The 13th payload was mounted immediately behind the GAS bridge on the starboard side of the Orbiter on an adapter beam.

In early 1984, it was felt that enough GAS paylcads had been flown to support an experimenters symposium. The GSFC in Greenbelt, Maryland was chosen as the location. An announcement and call for papers was soon mailed and the first GAS symposium was held at Goddard on August 1 and 2, 1984. Some 200 people attended representing 10 nations. Twenty-four papers were presented. A banquet was held at the Goddard Recreation Center with Col. Bryan O'Connor, USMC, as the after dinner speaker. Response to the symposium was enthusiastic throughout the GAS community, and a second symposium was held on October 8 and 9, 1985. Nearly 300 people from 15 nations attended, and 33 papers were presented at the second symposium. Once again a banquet was held with Commander Donald Williams, USN, as the after dinner speaker. In its desire to maintain the open nature of the program, NASA does not require that GAS experimenters provide a report following the flight of their payload. The proceedings published at GAS symposiums serve as the historical record of the GAS program.

By the end of 1984, 29 GAS payloads had been flown on 7 of the 14 STS missions flown by that time, not including the Flight Verification Payload. The pace picked up considerably in 1985. Beginning with the launch of STS 51-D on April 12, 1985, and continuing through the launch of STS 61-B on November 26, 1985, twelve GAS payloads were flown. The twelve payloads and one engineering container scheduled to fly on STS 61-C were installed aboard the Orbiter Columbia in readiness for the planned launch on December 18, 1985. Following a series of delays, STS 61-C was eventually launched on January 12, 1986. A total of 24 GAS payloads were flown, integrated and installed aboard Orbiters during 1985. Out of those 24 payloads, 8 flight assignments had been made with normal operating timelines with about 6 months elapsing between flight assignment and launch. The other 16, including the 13 payloads flown on STS 61-C, were manifested as payloads of opportunity on fairly short notice, ranging from 2 to 4 months elapsed time between flight assignment and launch. By the end of January 1986, a total of 53 GAS payloads and two engineering payloads had been flown on 14 missions out of 24 missions flown.

Two of the GAS payloads flown during 1985 represent a significant new capability offered by the GAS program, the ability to launch a small satellite from a GAS container. Considering the relatively low altitude of Shuttle missions, GAS satellites are short lived having a predicted useful on orbit life of 2 months to a year. To support this new capability two major new hardware designs were required. One was a pedestal which supports the satellite and attaches to a modified lower end plate mounted on a standard GAS container. The satellite is clamped to the pedestal by means of an Marman band which is released by explosively actuated bolt cutters. Separation force is provided by a spring, and a guide rod assures that the satellite will be pushed straight out of the container. In order to provide the maximum possible available diameter to the satellite, a modified MDA was designed and fabricated. Known as the Full Diameter Motorized Door Assembly (FDMDA), this new mechanism allows the entire inside diameter of the container to be used. However, the FDMDA cannot be sealed, and does not offer a choice of internal atmospheres to the experimenter as does the MDA (see figure 3). The first experimenters to launch a GAS satellite were a group of engineers, scientists, educators, and students from Northern Utah who dubbed their satellite NUSAT. The NUSAT group participated in the pedestal design under NASA review. The Marman band release system was adapted from a design proven and used many times in the Delta Rocket program, and the FDMDA was adapted from the MDA design. How much GAS satellites will become a part of the program remains to be seen, but there have been numerous inquiries to date and NASA is beginning to work with specific GAS satellite payload requests. As is the case with the MDA, an optional services charge will be made for use of the GAS satellite ejection system, and it will be intended to cover the actual costs of refurbishing the system for reuse. That charge has not been formally specified at this time.

The GAS program is now well established and is accumulating a respectable history. Intended as a means to assist in using the Orbiter to capacity, and opening the doors to those who previously had no opportunity to work in space, the program has served those ends very well. Many young engineers and scientists who worked on GAS payloads as students are now employed by NASA, its contractors, and associated universities. New GAS payload reservations continue to be made on a regular basis. Today there are 458 unflown payload reservations, 53 payloads have been flown, and 68 payloads are undergoing review at Goddard.

With a hardware inventory sufficient to handle multiple missions, an experienced support team throughout NASA and its contractors, and with experimenters steadily working their way through the review and certification process, the GAS program stands ready to meet the new challenges and flight assignments that will come its way in the future.

## SUMMARY

To summarize, the GAS program is clearly the least expensive, most straightforward means available for flying a small experiment aboard a Space Shuttle mission. While 13 months is the normal timeline for review and certification of a GAS payload, if the payload is extremely simple, having no significant safety hazards, or if the payload has been certified and flown on a previous Shuttle mission, it is sometimes possible to go from concept to installation in the Orbiter in a very short time. The current record for that effort is 60 days, held by a payload that had been flown previously. If your payload can be done within the parameters of the GAS program, and you can tolerate the waiting period imposed by the queueing system, the GAS program may well be your Low-Cost Route to Orbit.

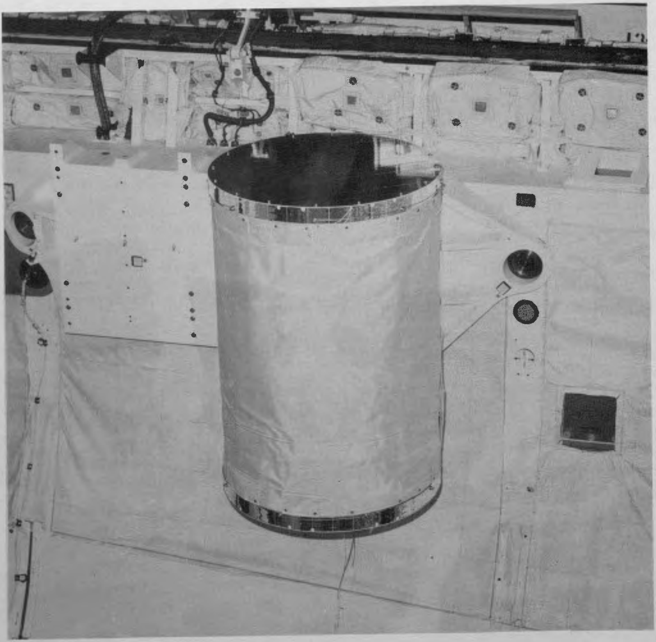


FIGURE 1 - GAS payload G0001 attached to the adapter beam, and installed in the Orbiter Columbia prior to flight on STS-4.

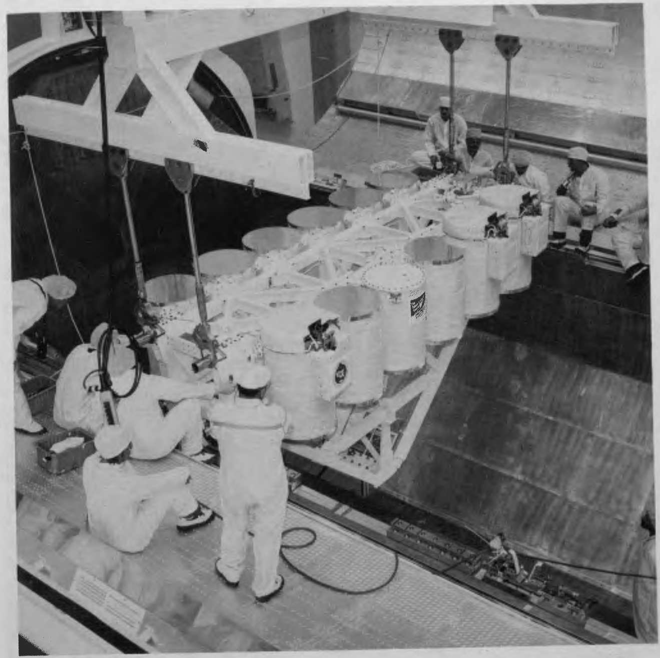


FIGURE 2 - The GAS bridge, with a full complement of 12 payloads, being installed into the payload canister in preparation for Mission STS 61-C.

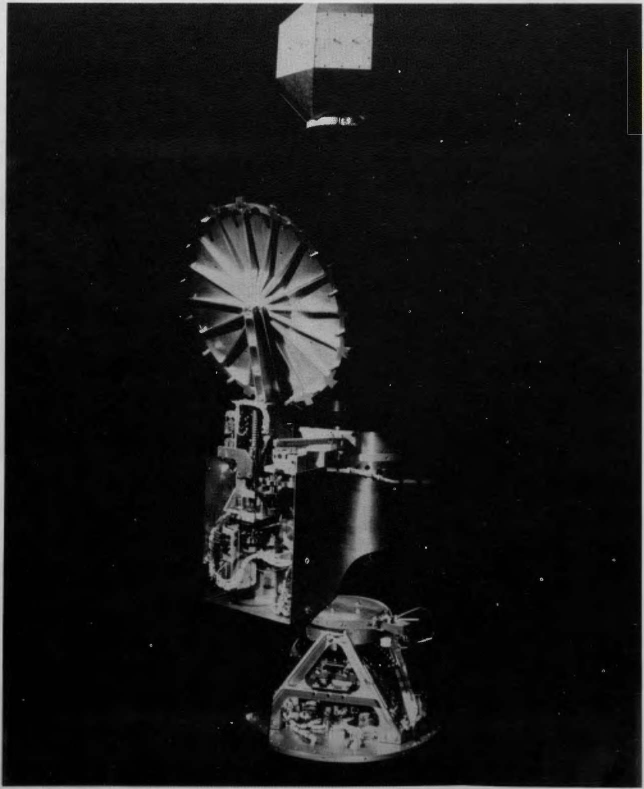


FIGURE 3 - The Structural and Mechanical components required to support the ejection of satellites from GAS containers, including the structural test version of the NUSAT satellite.

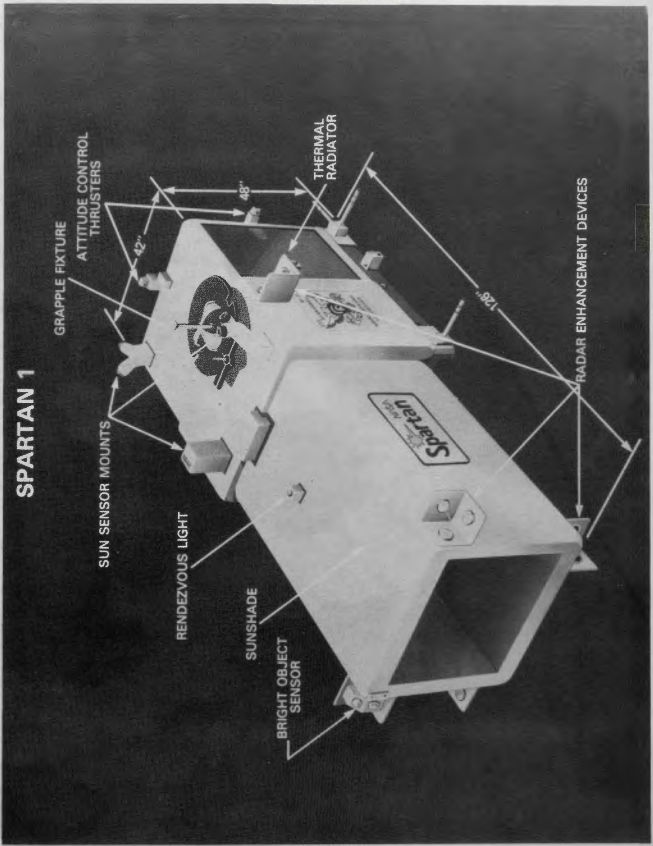

SPARTAN 1
SUN SENSOR MOUNTS
GRAPPLE FIXTURE
ATTITUDE CONTROL
THRUSTERS
42"
48"
THERMAL
RADIATOR
126"
RADAR ENHANCEMENT DEVICES
RENDEZVOUS LIGHT
SUNSHADE
BRIGHT OBJECT
SENSOR
Spartan
NASA

Figure 1

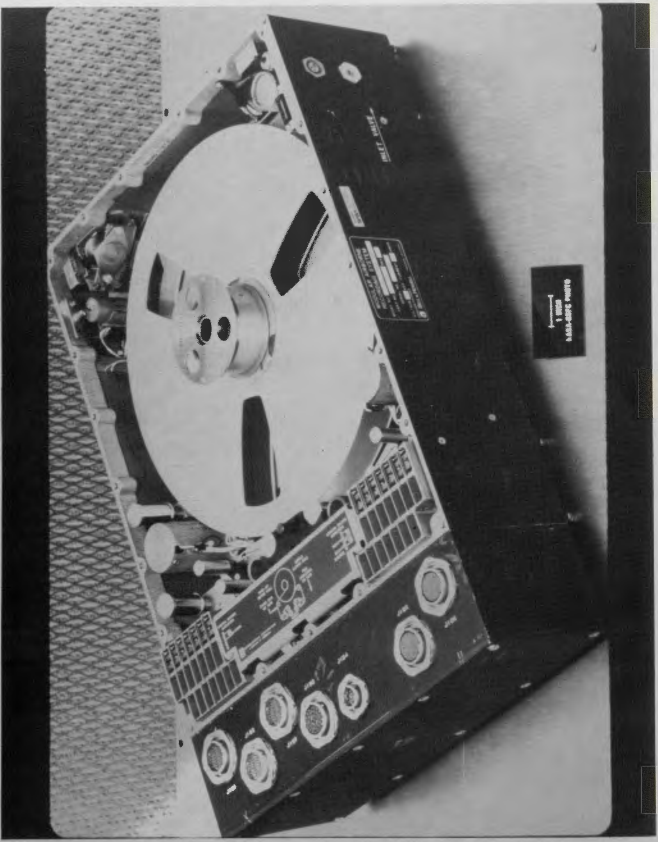



Figure 2

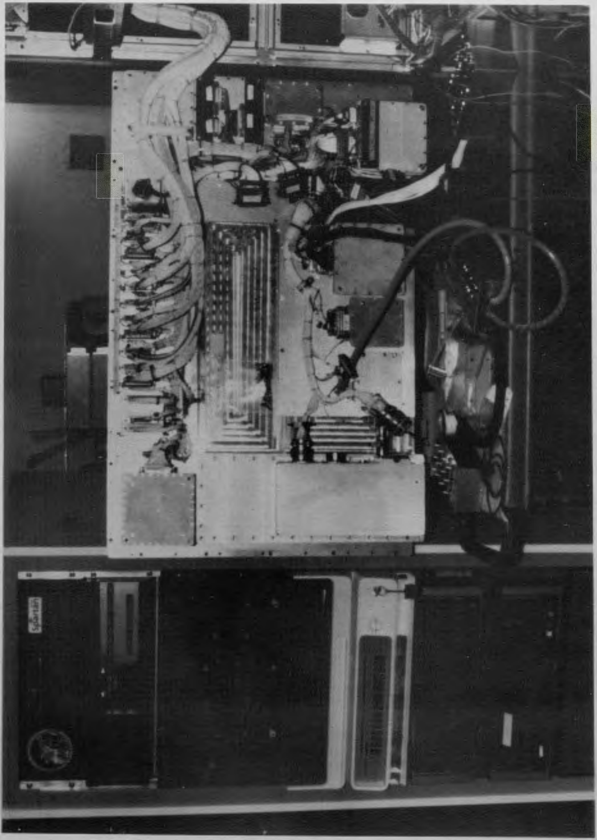


Figure 3

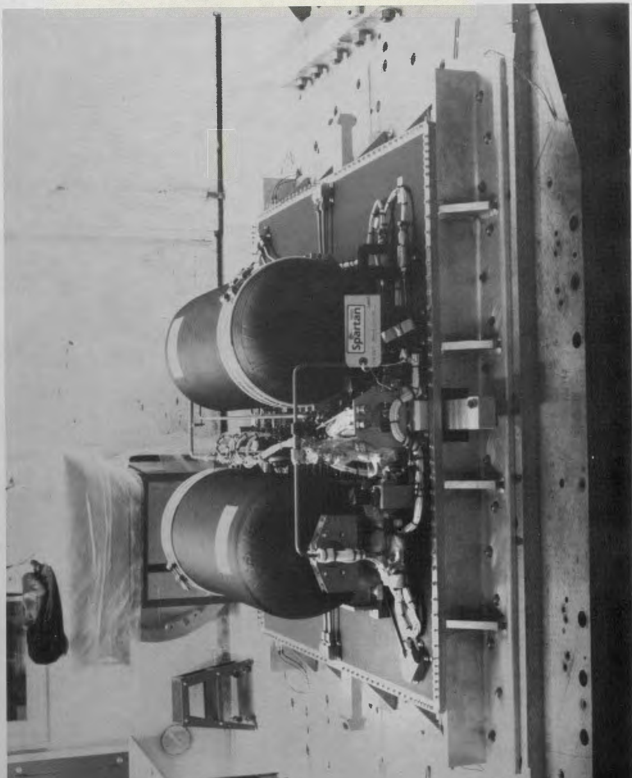



Figure 4

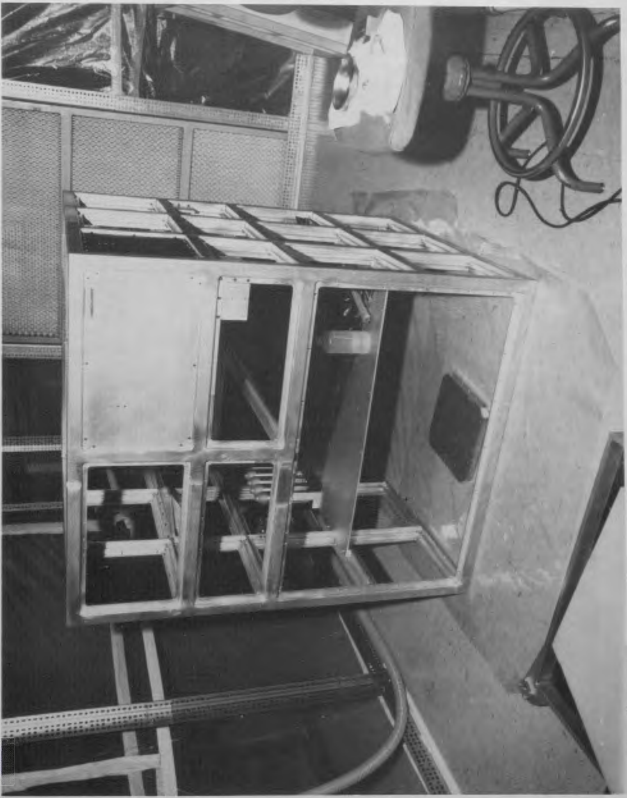



Figure 5

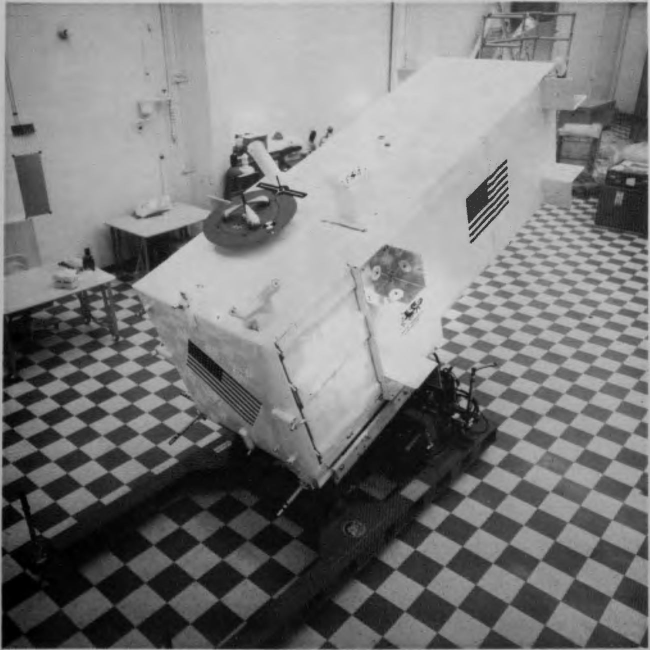


Figure 6

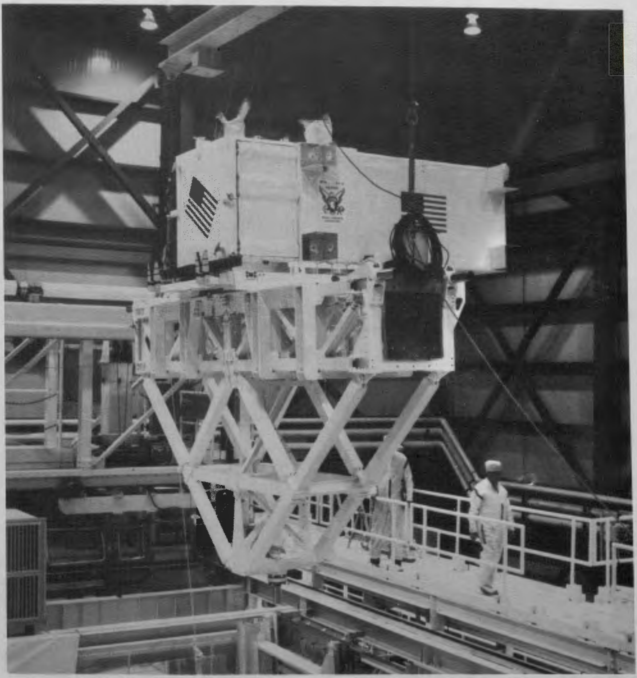


Figure 7

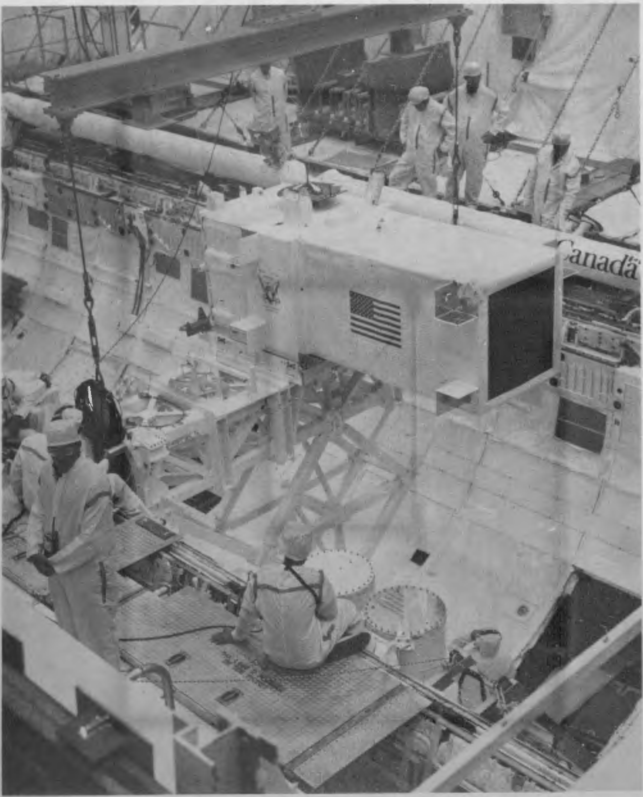



Figure 8

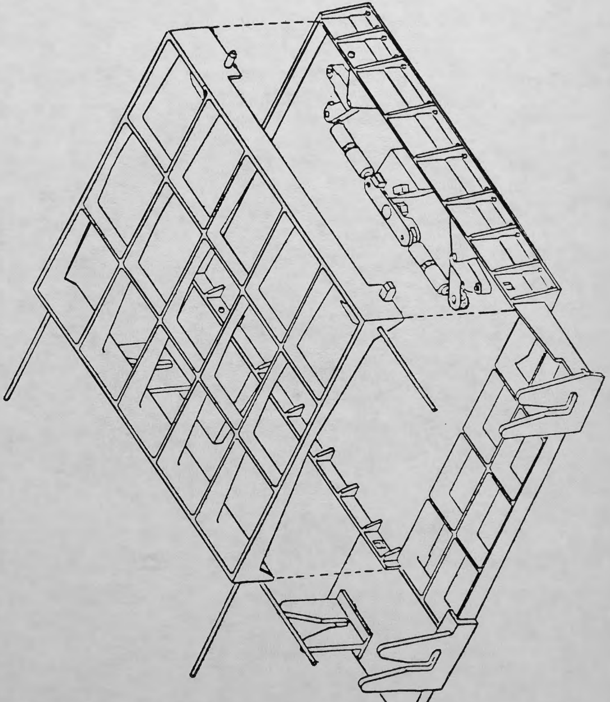


Figure 9

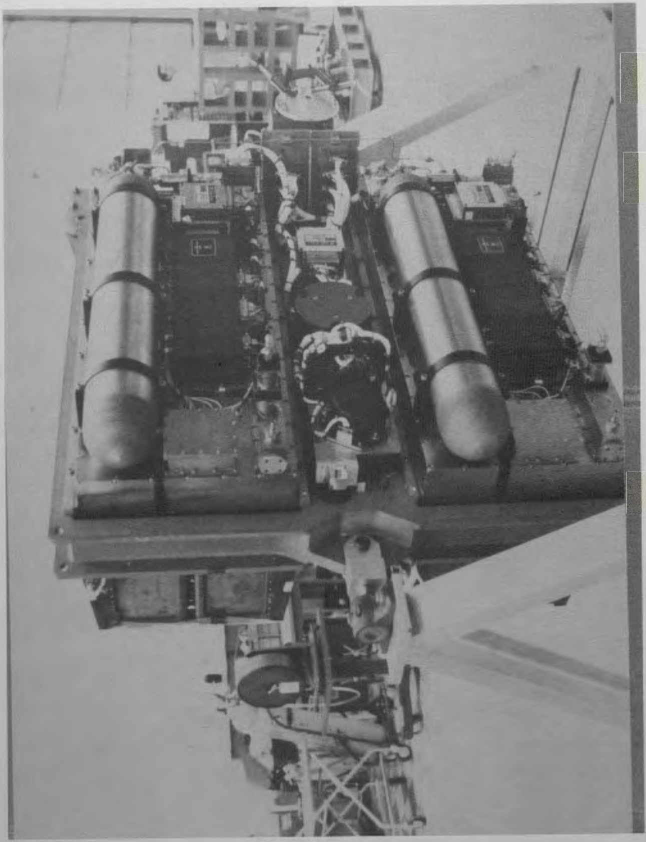


Figure 10

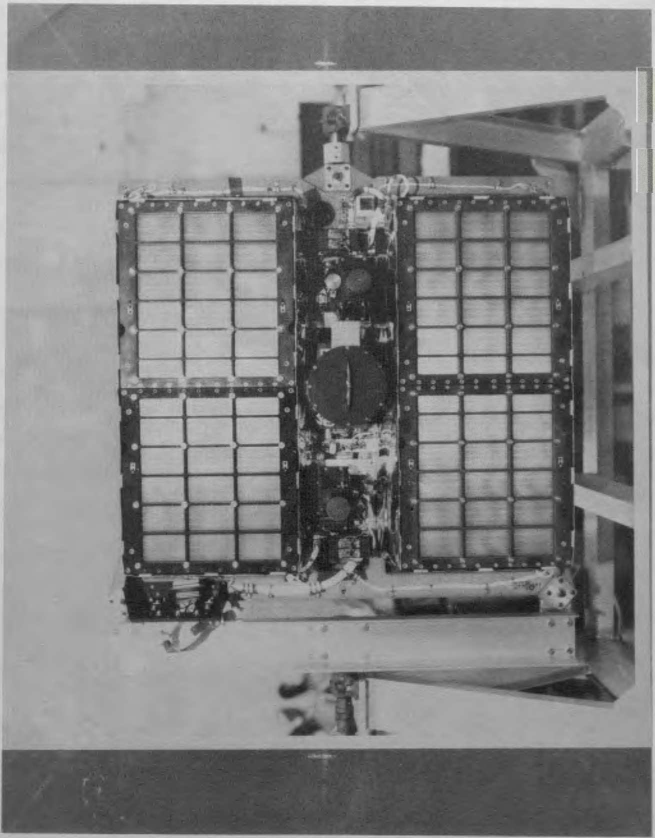


**Figure 11**

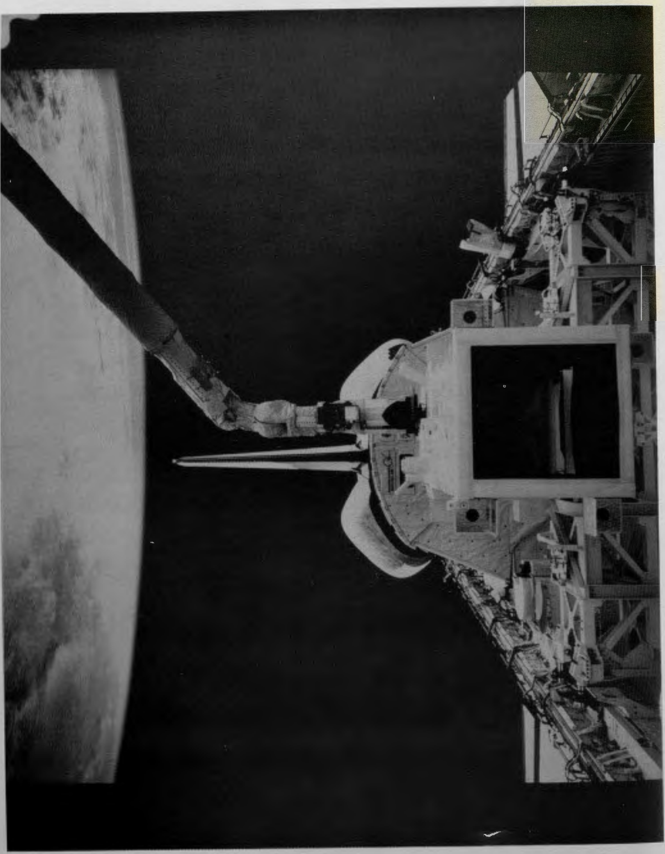


Figure 12

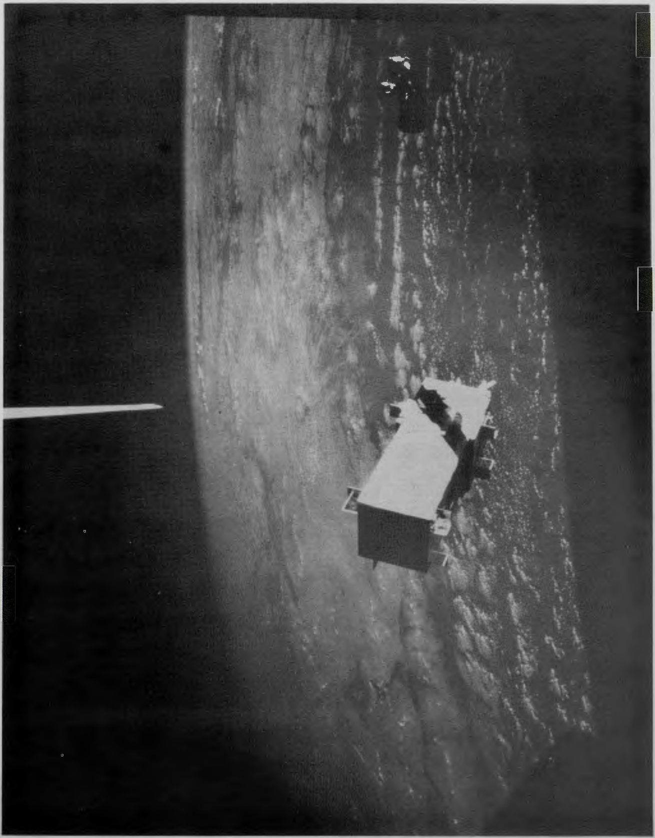


Figure 13

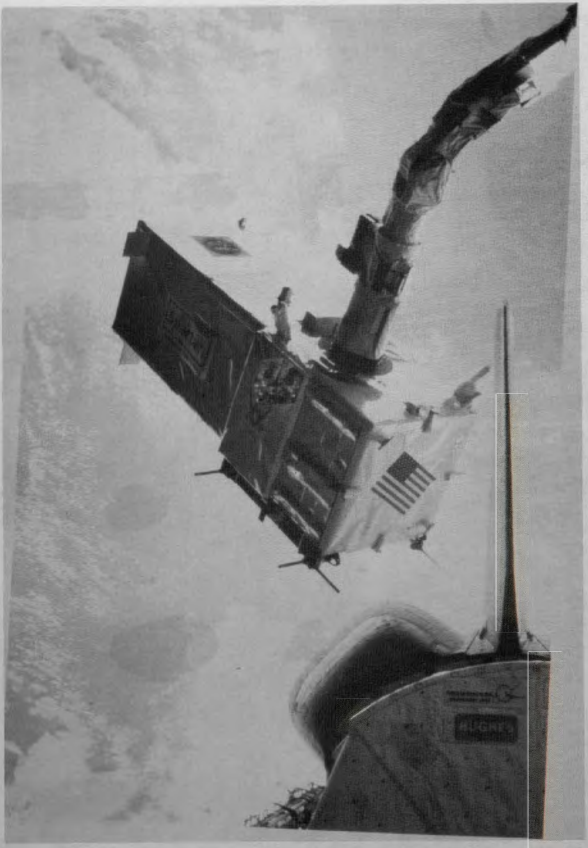
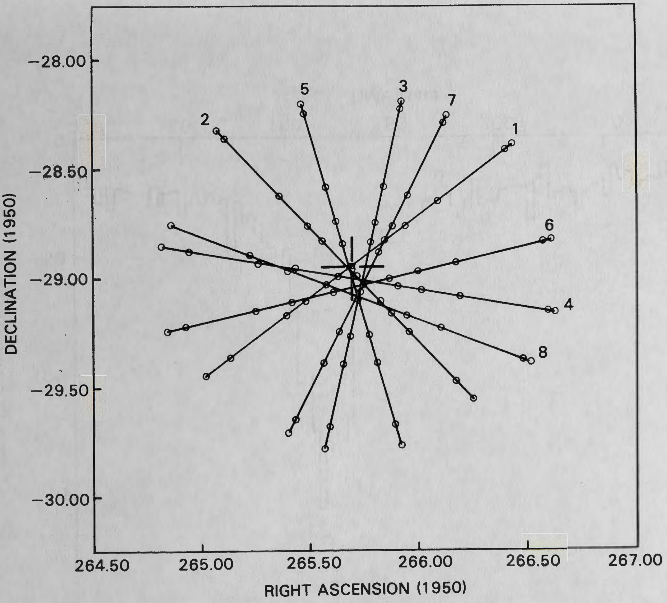


Figure 14



−28.00
−28.50
−29.00
−29.50
−30.00
DECLINATION (1950)
264.50
265.00
265.50
266.00
266.50
267.00
RIGHT ASCENSION (1950)
1
2
3
4
5
6
7
8


Figure 15

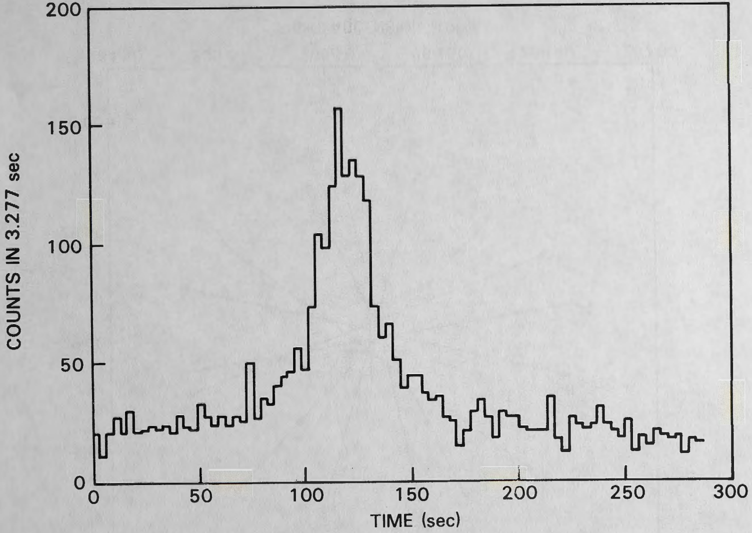
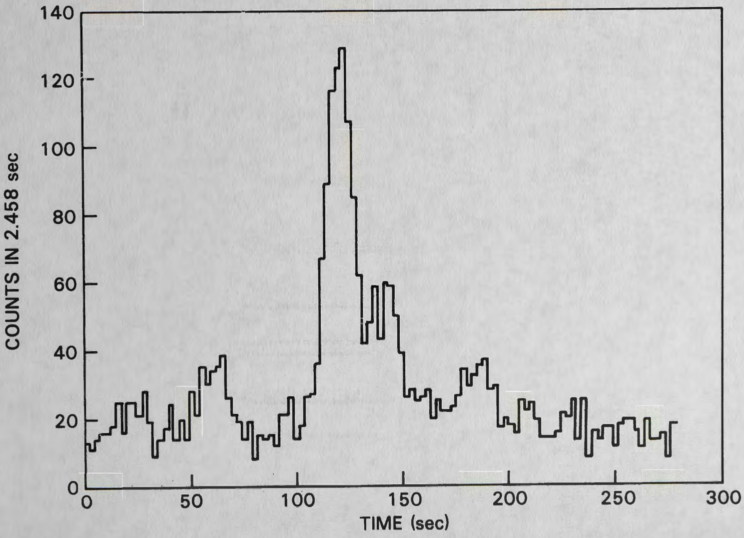

COUNTS IN 3.277 sec
200
150
100
50
0
0
50
100
150
200
250
300
TIME (sec)

Figure 16


COUNTS IN 2.458 sec
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20
40
60
80
100
120
140
0
50
100
150
200
250
300
TIME (sec)

Figure 17

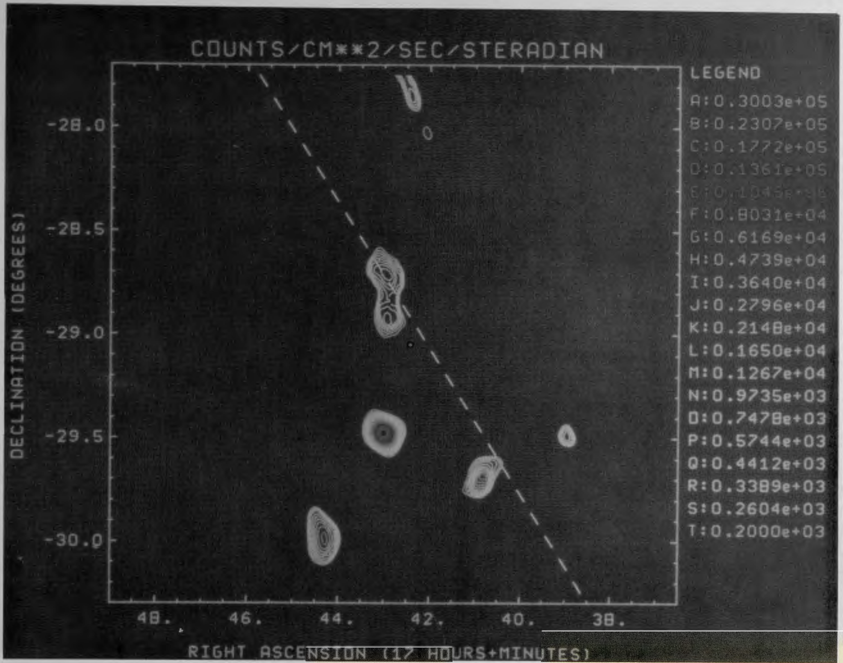
COUNTS/CM**2/SEC/STERADIAN
LEGEND
A:0.3003e+05
B:0.2307e+05
C:0.1772e+05
D:0.1361e+05
F:0.8031e+04
G:0.6169e+04
H:0.4739e+04
I:0.3640e+04
J:0.2796e+04
K:0.2148e+04
L:0.1650e+04
M:0.1267e+04
N:0.9735e+03
O:0.7478e+03
P:0.5744e+03
Q:0.4412e+03
R:0.3389e+03
S:0.2604e+03
T:0.2000e+03
-28.0
-28.5
-29.0
-29.5
-30.0
DECLINATION (DEGREES)
48.
46.
44.
42.
40.
38.
RIGHT ASCENSION (17 HOURS+MINUTES)

Figure 18

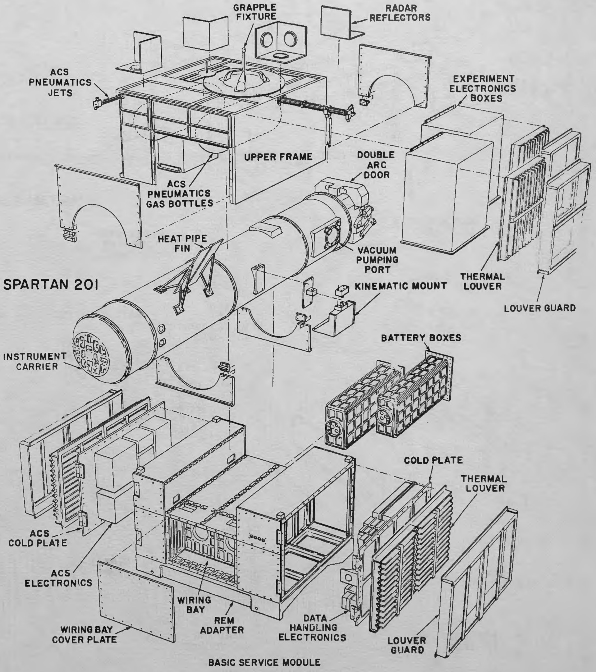


Figure 19
Spartan 201 configuration
with Solar Telescope.

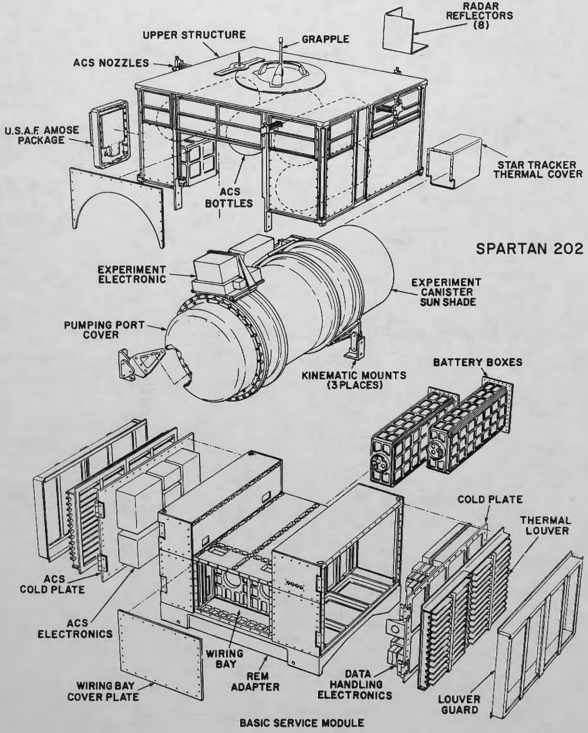


Figure 20
Spartan 202 configuration with Galactic Astronomy experiment.